same time indicates the position of the Ctenophora among the other classes of Radiata.

Polypi.	Acalephæ.		Ctenophora.	Echinodermata.
		Steganophthalmata.		
	Lucernariæ.			
		Gymnophthalmata.		

IV.—*On* Amœba princeps *and its Reproductive Cells, compared with* Æthalium, Pythium, Mucor, *and* Achlya. By H. J. Carter, F.R.S. &c.

[Plate III.]

During the month of April, 1863, I found *Amœba princeps*, Ehrenb., plentifully distributed in a shallow stagnant pool filled with dead leaves and fresh green confervoid Algæ, forming part of a chain of such pools, which, connected by a dribbling little stream, extended, for about half a mile in length, from a heath-bog, which it drained, to a little rivulet in the neighbourhood.

Although this *Amœba* is the largest freshwater species known, and stands figured in my journal at its commencement, viz. in 1854, as well as, at intervals, in many other places up to the present time, I have never until lately given the amount of attention to it that I have long since done to the other freshwater Rhizopoda, both naked and testaceous; nor in the present instance, probably, should I have gone further, had I not discovered in it cells which must be assumed to be reproductive, and had I not been recently studying the family of Fungi called "Myxogastres" with reference to the observations of M. A. de Bary, who found them so nearly allied to *Amœba* that he has proposed for them the name of "Mycetozoa"*.

Well acquainted, therefore, with most of the Myxogastres which have been described, but more especially with that species called *Æthalium*, I took the first opportunity which presented itself of comparing its structure with that of the largest form of *Amœba*; and hence my late study of *A. princeps*, of which I have only time now to give the results. The observations were all made on *Amœbæ* which had not been kept in confinement beyond four or five days.

It may be remembered by those who have read my "Notes on the Organization of Infusoria, &c."†, that I have therein

* Ann. Nat. Hist. vol. v. p. 233 (1860).
† *Ibid.* vol. xviii. p. 115 (August, 1856).

proceeded upon a certain nomenclature of their parts generally; and I shall pursue the same course here in the description of *A. princeps* specially.

The minimum and maximum size of *A. princeps* may be set down, according to my observations, at $\frac{1}{450}$th and $\frac{1}{25}$th of an inch in length, respectively, the breadth being a little less. Of course, these measurements may be exceeded either way; but I have not met with any larger or smaller specimens in which the distinguishing character of the nucleus, which will be presently mentioned, could be detected.

The most conspicuous features of *A. princeps* (Pl. III.), when it is large, are its size and the number of granules it contains, in both of which characters it much exceeds any other *Amœba* with which I am acquainted. Its form, of course subject to protean changes, is for the most part limaceous, or once or twice branched, and its pseudopodia, which are almost always lobed and obtuse, proceed from a posterior end which is normally capped with a tuft of villous prolongations; while the distinguishing character of the nucleus, to which I have above alluded, consists in the nucleolus (fig. 3 *d*) being so much extended over the inner surface of the nuclear cell that it passes beyond the equatorial line of the latter, and thus causes the pellucid halo which is seen round the nucleus of other *Amœbæ* to be absent; that is, the nucleolus, being circular and of much less extent than the hemisphere of the nuclear capsule, in most *Amœbæ*, causes it to appear in them as if surrounded by a transparent area—which, for the reason above stated, is not the case in *A. princeps* at the time when it has attained the $\frac{1}{450}$th part of an inch in length. Besides this, the border of the nucleolus in *A. princeps* at the same period is wavy; and this gives rise to an irregular transparent area in the nucleus or nuclear cell. Whether the nucleolus of *A. princeps* presents the appearance of that in other *Amœbæ* before this period is a matter of little consequence, inasmuch as, below the minimum size mentioned, all *Amœbæ* appear to be alike.

Ehrenberg's* and Dujardin's† figures of *A. princeps* are good representations of it.

Having thus briefly premised a specific description of *A. princeps,* let us now give our attention, severally, to the parts of which it is composed, under the following heads, viz.:—*Pellicula, Diaphane, Sarcode, Moleculæ, Granules, Digestive spaces, Fat-globules, Vesicula, Nucleus, Reproductive cells,* and *Spermatozoids.*

Pellicula.—Inference leads us to the conclusion that there is

* Infusionsthierchen, Atlas, fol., tab. viii. fig. 10 (1838).

† Hist. Nat. des Zoophytes, Atlas, pl. 1. fig. 11.

a pellicle over the surface of *A. princeps,* however thin; and the fact that very frequently, on the application of iodine, the margin becomes of a deep violet colour, while all the other parts of this Rhizopod exhibit nothing but a more or less deep amber tint, seems to confirm it by chemical differentiation.

Such a covering has been demonstrated by Auerbach in *A. bilimbosa**, and more satisfactorily, on account, probably, of the pellicula in this species being more rigid; but Auerbach does not show that it is coloured by iodine, although he figures starch-globules thus turned blue within it. Some years since, too, I pointed out the presence of starch, in all forms, throughout *Spongilla,* which is but a congeries of amœbiform cells. I have also shown that it exists in the chambers of the Foraminifera; so that starch may be set down as a common product of the Rhizopoda.

Returning to the pellicula, we must also infer that it is possessed of great elasticity and tenacity, so that it can yield a covering to the pseudopodia almost to any extent (as proved by the actinophorous rays of those Rhizopods which infest the cells of plants remaining after the sarcode has withdrawn itself into an interior or secondary cell); also that it admits of rupture (as in the introduction of food into the sarcode), and yet can heal over rapidly again. Thus it can undergo comparatively unlimited extension even to discontinuity, but possesses no adhesiveness externally, as evidenced by nothing adhering to it which is not seized and kept there by the instinct of the animal.

Furthermore, in *A. princeps* the pellicula is allied to the cell-wall of plants by position, and, from chemical evidence (*i. e.* when treated with iodine), by an amylaceous composition.

Diaphane or *Ectosarc.*—This layer, as in other *Amœbæ,* lies immediately underneath the pellicula, and is distinguished from the sarcode or endosarc within by its greater degree of transparency and peculiar functions; for while the sarcode is clouded and presents a rotatory motion, the diaphane is clear and distinctly endowed with a locomotive and prehensile power.

Analogy and actual observation would lead us to infer that, in certain if not in all instances, the ectosarc has the power of passing *through* the pellicula by rupture of the latter—a fact which becomes most evident when the pellicula is thick and resistant, as in *Amœba bilimbosa,* where it has been demonstrated by Auerbach, especially in his third figure of this species†.

* Siebold und Kölliker's Zeitschr. vol. vii. p. 365, pl. 19. figs. 1–5. (Dec. 1855).

† *Loc. et tab. cit.*

Contractility of the Diaphane.—On one occasion, while looking at a large specimen of *Amœba princeps,* I saw a rotatory animalcule, something like *Furcularia forcipata,* Ehr., come up to and bite it; and immediately after the bite had been given, the surface of the *Amœba* became puckered slowly towards the point bitten. The *Furcularia* then left the *Amœba,* but returned again and inflicted the same kind of injury, when the same evidence of contractility of the surface of the *Amœba* took place; and this was repeated several times, at short intervals, until I was fully convinced that the surface of the *Amœba* manifested the same appearance of irritability as muscular tissue under a similar stimulus. I made at the time a sketch of the *Amœba,* which had a peculiar form of the villous tail; and the whole is introduced in Pl. III. fig. 5, to make the facts connected with it more intelligible and impressive.

Sarcode or *Endosarc.*—This also, as in the other *Amœbæ,* is clouded, from several causes, but more especially from the presence of the *moleculæ* or fine granules, with which it is so densely charged that they seem to occupy half its bulk, and thus give it an amount of opacity which contrasts forcibly with the transparent diaphane. Moreover, the sarcode suspends the granules, digestive spaces and food, fat-globules, vesicula, and nucleus, all of which rotate with it, and, in addition to the rotatory movement especially, also contrast it strongly with the diaphane.

Granules.—These, which far exceed the moleculæ in size, have such a rounded form and dark outline at the commencement that they bear the appearance of organic bodies. But from round they become elliptical, and lastly angular and crystalloid aggregates, based upon an octahedral form, which in some instances is so perfect and so like that of *oxalate of lime,* that, with their pinkish colour and dissolving without effervescence under the influence of nitric acid, I am inclined to think that they are crystals of this salt. (Pl. III. fig. 1 *a,* & *g, h, i.*)

They are present in the youngest as well as in the oldest forms, and in number and size do not appear to bear any constant relation to the age and size of the individual; for they are sometimes more prominent even in young than in old specimens; but, as a general rule, perhaps they keep pace in number and size with the age of the *Amœba*: certainly, however, they do not pass into the crystalloid angular form until the individual is pretty large and well advanced in life. The largest I have met with did not exceed the $\frac{1}{2000}$th part of an inch in length, and was composed of an irregular crystalline aggregate based apparently upon an octahedral form. Their crystalloid form has been long since (1855) figured and pointed out in *Amœba bilimbosa* by Auerbach*.

* Loc. cit. tab. xx. figs. 12, 13.

These "granules" are common to all the freshwater Rhizopoda (including the amœbous cells of *Spongilla*), and for the most part present, at the commencement at least, a greenish tint. Nor are they less common in *Plœsconia*, *Stylonychia*, *Paramecium*, and perhaps in all the Protozoa. In *Paramecium Aurelia* they often present an acicular form, in bundles within true cells (if the latter are not globular dilated spaces in the sarcode); and here, too, they dissolve without effervescence under the influence of nitric acid. *Stylonychia*, when becoming encapsuled and taking on the "still form," gets them down towards its posterior extremity, from which they are frequently and finally discharged *en masse* into the capsule, with other refuse, which probably the *Stylonychia* finds it disadvantageous to retain in the sarcode during this passive state of its existence.

In *Æthalium*, one of the Myxogastres to which I have alluded, there is also a great development of small, round, colourless, compound, crystalloid masses, which, from their appearance and ready effervescence under the influence of nitric acid, I infer to be composed of carbonate of lime.

These, probably, are analogous to the "granules" of the Rhizopoda, and the whole, perhaps, to the *raphides* of plant-cells; in which case we have another point of resemblance between *Amœba* and the latter.

Fat-globules (Pl. III. fig. 1 *k*).—I would apply this term to certain yellowish, semiopake, refractive spherules, which appear in considerable number in the sarcode of *Amœba princeps*, and perhaps, more or less, in all the freshwater Rhizopoda. They have always seemed to me much less prominent in appearance in *A. princeps* than the "granules," although frequently exceeding many of the latter in size; but their sphericity, yellowish colour, and semiopacity sufficiently distinguish them from the "granules."

They have also always appeared to me largest and most numerous where the *Amœba* has been most robust; and hence I am inclined to infer that they are analogous to the fat-globules of the plant-cell, more especially to those which occur about the green bands of *Spirogyra* just previous to conjugation of the filaments and spore-formation, evidencing an accumulation here of nutritious matter for this purpose. And I think that I have observed them to be most numerous in *A. princeps* just about the time of the development of the reproductive cells, which will presently be described.

Here then, again, would appear to be another point of alliance with the plant-cell, viz. the presence of these "fat-globules," although not more here perhaps than with any other cell.

Digestive spaces.—Of these I need state no more than that the diaphane of *A. princeps* seizes the nutritious body, whether living or dead, animal or plant, of its own kind or different, surrounds it and encloses it, with a portion of water, within its substance, and then *apparently* opening a way for it into the sarcode, finally transfers it to this organ, where it appears, surrounded by the water taken in with it, in a spherical form, undergoes digestion so far as it admits, and leaves the egesta to be cast off by the diaphane in much the same way (only inverted) as they were incepted.

One point here is remarkable, viz. that while any part in front of the villous or posterior end may enclose a particle of food, it is only, so far as my observation extends (and in this I am confirmed by Dr. Wallich*), the posterior extremity which gives passage to the egesta.

This is the grand difference between *Amœba* and the plant-cell, viz. the inception of crude food, and the evacuation of the egesta.

I would also add another observation here, viz. that the presence of the fragment of food does not necessarily involve the evident presence of a digestive space round it; for frequently the particle appears to be in direct contact with the sarcode. In our comparing, then, *Æthalium* (which always, until just before fructification, does contain particles of foreign and apparently nutritive matter) with *Amœba*, it is not against the similitude that the former should not have any digestive spaces around the particles of foreign matter which it contains, as this does not prove that these foreign particles are not really serving as nutriment. I have not only constantly seen microscopic fragments of what appeared to me to be the nutritious parts of woody structure in the general mass of *Æthalium*, but on pricking its rhizopodous processes, and obtaining the protoplasmic contents, which immediately burst forth and assume a coagulated globular shape, have found the same, when carefully transferred to the field of a microscope, to contain the particles of foreign matter to which I have above alluded. I, therefore, can come to no other reasonable conclusion than that they were taken in by the *Æthalium* for nutrition, as much as the fragments of nutritious matter which are incepted by *Amœba*,—a point which, if satisfactorily proved, entitles the Myxogastres, more than anything else, to claim for themselves the name of "Mycetozoa," which, as already stated, has been proposed for them by M. A. de Bary.

Observations.—Having now described the sarcode and its proper contents, viz. the moleculæ, granules, fat-globules, and digestive spaces, we will defer the vesicula and nucleus for after-

* Ann. Nat. Hist. vol. xi. p. 436 (1863).

consideration, while, for a short time, our attention is directed to the peculiar function of the sarcode and its motion in connexion with that of the diaphane, and also to the theories that have been adduced to account for the wonderful phenomena which they present.

Of the "peculiar and particular function" of the sarcode there can be no doubt, viz. that of digestion; for we may watch this, from the inception of the food, through its being broken down by the solvent process, to the ejection of the refuse. But, by analogy, it would appear to have another function; else why should its rotatory motion go on unceasingly, like that of the protoplasm of the plant-cell, to wit, in *Nitella*, where it is not called upon to exercise the function of digestion? The other function, then, that I would attribute to the sarcode is that of aëration or respiration. In *Æthalium*, the rapidity with which the sarcode and its contents continually rush round the interior of the massive portions, as well as through the minutest arborescent branches, is astonishing; nor does it cease for a moment, under ordinary circumstances, until all is prepared for the last change of form, viz. that for fructification, when life is about to become extinct from everything but the bits of protoplasm wrapt up in the little sporidia, for the future perpetuation of the species. Such is also the case with *A. princeps*, although there are certain short intervals of cessation which take place, *ex. gr.* when this Rhizopod is much disturbed; and it is worthy of notice that the movement in the sarcode at these times does not commence until the diaphane has also commenced to transform the *Amœba*.

As regards the composition of the diaphane and sarcode, Max Schultze some time ago put forward the theory that they were composed of protoplasmic nucleated cells, which, coalescing on the surface, formed the transparent diaphane, but gradually retained more of their cellular individuality inwardly, where they formed the sarcode; so that, in short, the diaphane and sarcode thus pass into each other *.

On the other hand, Reichert, whose observations here are confined to the Foraminiferous Rhizopods, is of opinion that the diaphane or pseudopodia are composed of extremely minute filaments which do *not* coalesce, but, from their plasticity and transparency, adhere to each other with such mutual adaptation that their individual forms cannot be distinguished under circumstances of combination, while they always retain their primitive form under separation †.

* Ann. Nat. Hist. vol. vii. p. 318 (1861); translated from Wiegmann's Archiv, 1860, p. 287.

† Ann. Nat. Hist. vol. x. p. 403 *et seq.* (1862); translated from the 'Monatsbericht der Akad. der Wissenschaften zu Berlin,' 1862, p. 406.

Lastly, Dr. Wallich, in his late interesting and indefatigable study of *A. villosa,* thinks that the diaphane and the sarcode are mutually transformable into each other, as the occasion may require*.

Now, the worst of theories is, that they take up so much time in discussion before they bring out fact; while the best of them is, when multiple, that they prove that the fact is still unknown.

I shall therefore not enter further upon these speculations, as the reader can best form his own opinions of them by reference to the papers which contain them *in extenso,* and will only add, on this subject, that, as the diaphane is formed from the sarcode, it seems to me probable that the former has a distinct structure as well as office, and that, having been produced, it is not reconvertible into any other organ by any process but digestive assimilation. Thus, the leg of a *Plœsconia* has comparatively as much form and as many functions as a crab-claw; but it must not be assumed, because it is as transparent and apparently as structureless as glass, that it is composed of a structureless jelly-like substance which can be made to assume any form and take on any function that the animal chooses,—on the contrary, that it has structure and form, which the microscope, with all its optical powers and chemical tests, cannot at present define—that such structure and form is so inconceivably delicate, and its particles held together with such slight tenacity that, as a bunch of iron-filings kept in apposition by a temporary magnet falls to pieces when the galvanic circle is broken, so does the leg of *Plœsconia* undergo the same kind of disintegration, viz. *diffluence,* when its vitality is withdrawn—and that there is no returning of this leg to the original plasma with which it was formed, except by its destruction and re-assimilation. I, of course, assume that the leg of *Plœsconia* bears the same relation to *Plœsconia* that the pseudopod of the diaphane and pellicula bears to *Amœba,* viz. that it is merely a modified form of the external covering—the one permanent, the other transitory.

Again, there is another point here, with reference to the motion of sarcode, which it would be well to notice, viz. the source from which the rotatory motion is derived. It has already been stated that this motion stops with the cessation of the motion of the diaphane, and *vice versâ.* Is it possible that the sarcode is rolled round by some peculiar undulating movement of the diaphane, after the manner that the uneven wavy surface of the protoplasm in the cell of *Nitella* causes a rotatory movement of the axial fluid? I confess that at present I do not see anything

* Ann. Nat. Hist. vol. xi. p. 370 (1863).

to prove that the sarcode moves round by itself, unless we assume that its analogue the protoplasm of the plant-cell (ex. gr. in *Nitella*) possesses this property; and, bearing on this point, M. Garreau observes:—"In proportion as the merithalli [internodal cells] are developed, this matter [the rotating protoplasm] gets fixed to the primordial membrane, in the formation of which, indeed, it takes part, and which, though adherent to the cell-wall, propels onward the enclosed liquid of the cell, not, as has been suspected, by the aid of vibratile cilia, but by tolerably rapid undulations, similar to those produced on the surface of water ruffled by a gentle breeze"*. The primordial membrane supports the chlorophyll-cells in the internode, and retains them in their fixed position; but when the contents of the internode collapse under injury or death, this membrane leaves the internal surface of the cell-wall, here as well as in the root-cell, where there are no chlorophyll-cells—showing that it is still organized, and analogously placed to the diaphane in *Amœba*. I confess that M. Garreau's meaning is a little obscure here, *i. e.* as to whether by the "liquid of the cell" is meant the "axial fluid" or a remaining rotatory portion of the protoplasm. But his allusion to an undulatory power of a fixed membrane of the cell is distinct. How far his interpretation in this respect pertains to fact remains for future observation to determine.

Such, in conclusion, however, are our difficulties in the right appreciation of physical signs when we come down to this region of organized life, that, unless we can state in a few words the facts which we may wish to establish, it is useless to have recourse to long argumentative theories for this purpose.

In *Æthalium*, although of far greater tenuity than in *Amœba*, and therefore more nearly allied to the protoplasm of the plant-cell, there is still a homogeneous superficial layer corresponding to the diaphane.

Vesicula or *Contracting Vesicle* (Pl. III. fig. 1 *b*).—The normal number in *A. princeps* is one; but there are many smaller ones which act as sinuses around it, and one of these occasionally becomes so enlarged as to look like a second vesicula, yet it also ultimately discharges its contents into the main one. Where the vesicula discharges itself, it again recommences to appear; and there, also, the accessory sinuses may be best seen as they successively become dilated and discharge their contents into the vesicula.

It is a remarkable fact, that although the vesicula is borne round the interior of *A. princeps* with the sarcode to which it

* Ann. Nat. Hist. vol. x. p. 116; translated from 'Ann. des Sc. Nat.' tom. xiii. 1860, p. 189.

belongs, it only discharges itself in the neighbourhood of the villous or posterior end; and such is the case also with the egesta of the digestive spaces; so that one might almost infer that there was a particular aperture through the diaphane and pellicula at this part of the *Amœba* for this special purpose, as we see in most of the other Protozoa, where the vesicula is stationary, and frequently fixed close to the anal aperture.

Towards death the vesicula, growing weak, is not easily refilled, nor do the small sinuses which surround it readily discharge their contents into it; so that by a little pressure, when the group is at the margin, they may be made to pass out into the water without bursting; and at this time, if iodine be applied, each may be seen to retain its cell-form, puckered and tinted yellow by the iodine, although they may be all quite isolated and separated from the rest of the sarcode and from each other (figs. 10 & 11). Again, the fact of the dilatation of the vesicula always taking place at the point where it contracted, and the presence of condensed sarcode round the point of contraction, manifested under the effect of iodine, induce me directly and analogically to consider the vesicula as much a distinct organ in *Amœba princeps* as in other Infusoria. And if the vesicula be distinct, why not the sinuses?

All these dilatations are considered by my friend Dr. Wallich to be extemporized vacuoles. But I am glad to observe that he supports me in the opinion that the vesicula, at all events here, discharges its contents *externally**.

In *Æthalium* the vesicula, although present in the youngest forms, does not appear in the more matured and larger masses, so far as my observation extends.

Nucleus (Pl. III. fig. 3 *b*).—The nucleus in *A. princeps*, as before stated, differs in appearance from that of all the other freshwater Rhizopoda that I have examined, in the absence of a pellucid area round the nucleolus; and this arises, as before stated, from the border of the latter extending so much over the inner surface of the nuclear cell as to pass beyond its equatorial line, where it terminates in an undulating margin, which thus leaves a transparent, irregular area. At least, this is distinctly visible when the *Amœba* is not more than the $\frac{1}{450}$th part of an inch in diameter, viz. the minimum size above mentioned (figs. 3 & 3 *d*, &c.). Whether the nucleolus, before this, is circular and presents the usual pellucid area around it, or not, I do not pretend to determine, but I think it very likely; and then this state and the smallness of the *Amœba* would preclude all possibility of specific distinction: hence I do not think that there is any necessity for us to concern ourselves about the appearance

* *Loc. cit.* p. 441.

of the nucleus in *A. princeps* before it arrives at the size just mentioned.

At this period the nucleus is not larger than a human blood-globule, and the consistence of the nucleolus apparently homogeneous, that is, without granules, and composed of a fine delicate yellowish film of semitransparent plasma, in which state it continues, with the exception of increasing in bulk, up to the time when the *Amœba* has attained about one-tenth of the adult or maximum size, that is, about $\frac{1}{250}$th of an inch long (fig. 3, &c.).

The nucleus at this time may be about $\frac{1}{1200}$th of an inch in diameter; but it now undergoes duplicative division, which ends in the production of *two* nuclei of the same description as the original one, but each $\frac{1}{1800}$th of an inch in diameter (fig. 3 *b* & *f*), after which, subduplicative division appears to go on, until the *Amœba*, in its adult condition and size, may contain upwards of seventy of the kind of cells thus produced.

At the commencement, the division of the daughter nuclei does not appear to be always simultaneous; so that there may be two of $\frac{1}{1800}$th of an inch in diameter present, and one of twice this size, or six of $\frac{1}{1800}$th of an inch in diameter, and one of twice that size (fig. 5 *c*), indicating that the sum, if the large one had been divided, would have been a multiple by two. But however regular this may be at the commencement, as the numbers increase the sums do not agree. Thus I have distinctly counted upwards of 64 but much below 80, and above 32 but not exceeding 45 (figs. 1 & 4): hence the number of these cells present is not always a multiple of two. Still, whatever may be the cause of this, their diameter is, for the most part, constant, viz. the $\frac{1}{1800}$th part of an inch; being as often perhaps slightly elliptical as spherical, they may thus exceed this a little in the long axis; while their number corresponds with the size of the *Amœba*.

At first they are so delicate, and their capsule so undeveloped, that they present the appearance of cells composed of nothing but a fine, delicate, semitransparent, homogeneous plasma (fig. 1 *e*, & *l*, *m*, *n*); but as they grow older, this becomes granuliferous; and towards the adult state, there is a distinct capsule, from which (on dying) the granuliferous plasma withdraws itself into an elliptical form (fig. 4 *d*). All this may be more satisfactorily demonstrated by the addition of iodine, which gives the granuliferous plasma a deep amber tint; and I think, in some instances, I have seen it produce a violet one in the capsule, which otherwise remains transparent, uncoloured, and uncollapsed.

On no occasion have I been able to detect a nucleus in these cells, or anything like a germinal vesicle at any period of their existence—perhaps because it has eluded my search.

They roll round the interior of the *Amœba* with the sarcode in which they are suspended; and of course, when present, there is no nucleus to be seen with them (fig. 1). But, as they become matured, the *Amœba* grows slower and slower in its movements, until at last it becomes stationary (fig. 4). The pseudopodous prolongations are then only forced through the pellicula here and there, in a transparent, attenuated state (fig. 4 *c c*), the pellicula is thickened and corrugated, the rotatory motion of the sarcode has nearly ceased, and hardly any food remains in the interior; so that the parent *Amœba* is almost reduced to an effete capsule of reproductive cells. Beyond this point of development I have not been able to follow it, because, when the pseudopodous expansions of the diaphane cease, which is the next step, there is little to distinguish the mass from any other Infusorium in a similar condition.

But I presume, as I have before shown in *A. verrucosa*, &c., that the parent after this becomes wholly effete, and that these cells sooner or later become hatched into as many new *Amœbæ*.

Whether each cell yields one *Amœba* only, or whether the granules become enlarged into polymorphic ciliated cells which ultimately pass into *Amœbæ* respectively, but of smaller size, or whether some of these cells yield one only, and others a group of new *Amœbæ*, is left for future observation to determine. Both ways of propagation are common to the Rhizopoda; but all that I can do here is to show that the largest of our *Amœbæ* produces reproductive cells like the rest, and very similar to those of *Æthalium*.

Two kinds of "spherical corpuscles," also, have been noticed by Dr. Wallich in his *Amœba villosa*, viz. one termed "nucleated," $\frac{1}{3300}$th to $\frac{1}{1600}$th of an inch in diameter, colourless, without capsule, and consisting of a cell of "pale, nearly colourless, granular protoplasm," and the other termed "sarcoblasts," $\frac{1}{2000}$th to $\frac{1}{1650}$th of an inch in diameter, faint yellow, oily-looking at first, then colourless, also without capsule, but "distinctly granular and nearly homogeneous throughout"*.

Dr. Wallich also observed the ejection from *A. villosa* of minute young ones, $\frac{1}{2500}$th to $\frac{1}{1660}$th of an inch in diameter, with all the characters of the parent, even to the "villous tuft" †.

Can the former be the same with the "reproductive cells," &c.

* Ann. Nat. Hist. *l. c.* p. 435, pl. 10. figs. 5 & 6.
† *Ibid.* p. 442, pl. 10. fig. 10.

(fig. 1 *c, d*), which I have described? and could the latter have been some of these cells which had passed into young *Amœbæ* in the body of the parent?

Granulation of the Nucleus (Pl. III. fig. 2).—We come now to what is probably a granular propagative change taking place in the nucleus, without subdivision into the reproductive cells just described.

This change commences a little before the *Amœba* has arrived at half the adult size, and when the nucleus is about $\frac{1}{1800}$th of an inch in diameter. After this, the nucleus increases in bulk, as the granulation which is taking place in the nucleolus becomes more and more coarse and evident, until, towards the adult size above mentioned, it obtains an oval and apparently flattened form, about $\frac{1}{500}$th of an inch long (fig. 2 *f*). The capsule or nuclear cell has now become much thicker, and the granules of the nucleolus, which are spherical bodies composed of yellowish, semiopake, refractive matter, about $\frac{1}{14000}$th of an inch in diameter; but the *Amœba* at this period is as active as in any former part of its existence.

Of the ultimate development here also I am ignorant, but presume that here too the parent membranes become effete, and that the nucleus, bursting, gives freedom to the granules of the nucleolus, in the form of so many polymorphic ciliated cells, which, as in other similar cases, lose their cilia, and finally become reptant young *Amœbæ*.

Spermatozoids.—Lastly we come to this element; and although the act of generation, where there is a combination of the protoplasm of different cells, seems only to be the dividing up of the contents of one cell into smaller portions than that of the other, that the former may be added to the latter after the manner that increments of matter are added to a balance to make up a certain weight or quantity, still it is necessary for us not only to have this unequal division of the protoplasm into separate living organisms, but to see that they bear certain signs which distinguish the ovum and the spermatozoid, and then, if possible, that the two combine, before we be satisfied that such elements are for propagation by this process.

Now, as yet I have never seen (to my knowledge) either one or the other in *A. princeps*. I could perceive no germinal vesicle nor anything like a nucleus in the cells formed by the division of the nucleus; and I do not know what the form or course of the granules of the granulated nucleus may be in *their* ultimate development, or of the granuliferous cells which are seen among the reproductive ones (fig. 1 *d*). But I did see bodies for which I am not able to account, viz.:—

1st, Several granuliferous cells which were with the reproductive cells, but smaller in size. In two or three instances, but not constantly (fig. 1 *d*).

2nd. A single large transparent cell with small granulated nucleus, together with, but much larger than, the reproductive cells. Also not constant (fig. 1 *e*).

3rd. A single cell (containing an effete nucleus and several short bacillar filaments) a little larger than the reproductive cells, but present with them. Only seen in one instance. This looked more like an oscillatorial development inside the cell than one of spermatozoids (fig. 9).

4th. Lastly, I may mention here a spherule like the "fat-globule," which is occasionally discharged from the posterior extremity, and after exit, bursting, shows a distinct capsule, the contents of which separate into a group of minute, swarming molecules, which for some time adhere to the tail of the *Amœba*, and at last gradually, one by one, disappear (fig. 2 *e*).

But when we consider that *Amœba* takes in such a variety of organisms for food, it is evident that we should require in addition to have bodies which have distinct and persistent characters, occurring in the *Amœba* almost constantly, to determine those which do and those which do not form a part of the living animal. Therefore I only record the above observations for what they may be worth, and to show how far I have been able to go in the matter of spermatic development in *A. princeps*.

Villous appendage (Pl. III. fig. 1 *f*).—The villous appendage which marks the posterior end of *A. princeps* has lately been brought into notice by Dr. Wallich, in the species for which he has proposed the designation of "*villosa*"*.

This appendage is figured in my Indian Journal as far back as 1854, also many times since, as before stated, and consists of a number of minute villi, forming a cap-like tuft upon the posterior end of the *Amœba*. In one instance it appears as if it were composed of several long or large villi covered with smaller ones, thus forming as many tufts as there were large villi (fig. 5 *d*). Occasionally these tubular or villous extensions of the ectosarc are dilated into cellular forms, and then they give the posterior end of the *Amœba* a crenulated aspect (fig. 2 *d*), while at other times (although this is but seldom) there is little or no trace of them. They are present in the youngest (fig. 3′) as well as in the oldest active periods of the *Amœba's* life, and appear to be always accompanied by finger-like projections of the endosarc into them. When iodine is applied, they spread out into an even edge, like that of the rest of the *Amœba*. As Dr. Wallich has stated, they appear to have a rootlike or prehensile use. *Hydra viridis* has a tubular structure extending

* Annals, *loc. cit.*

from the endosarc to the external surface of the posterior extremity, to which the villi in *Amœba* may be analogous.

I am not quite certain that they are peculiar to *A. princeps,* although Dr. Wallich permits me to state that he now thinks his *A. villosa* is one and the same with *A. princeps.* Still I have a drawing of an *Amœba* which has them, but does not appear to have the characteristic form of the nucleus of *A. princeps.* If they are confined to *A. princeps,* then they form a good distinguishing feature for this species; but, as I have before stated, they are not always present under the same form, and sometimes not at all.

Instinct.—Low in the scale of organized beings as the Rhizopoda may be considered, there are manifestations of instinct occasionally evinced by them, of the same kind as those in the highest animals. Even *Æthalium* will confine itself to the water of the watch-glass in which it may be placed when away from the sawdust or chips of wood among which it has been living; but if the watch-glass be placed upon the sawdust, it will very soon make its way over the side of the watch-glass and get to it.

Here it should be premised that I regard all organic operations, even the development of the brain itself, as instinctive —that is, produced by the instinct originating in the protoplasm of the primordial germ from which each species may be respectively derived after impregnation. Nay, before, back to the finding of the ovules by their respective spermatozoids, I regard every act of this kind as much an operation of instinct as the building of a bird's nest, or the finding its way back for many miles direct by an animal, to a place from which it has never before been removed, viz. a power which exists before as well as after mind, and is only known by its manifestations.

Thus it is not wonderful that in the Rhizopoda such manifestations should present themselves; but as others may be inclined to call this "automatic," or to interpret them differently, I shall not go further into this matter now than to submit the following facts for consideration:—

On one occasion, while investigating the nature of some large, transparent, spore-like, elliptical cells (fungal?) whose protoplasm was rotating while it was at the same time charged with triangular grains of starch, I observed some actinophorous Rhizopods creeping about them, which had similarly shaped grains of starch in their interior; and having determined the nature of these grains in both by the addition of iodine, I cleansed the glasses and placed under the microscope a new portion of the sediment from the basin containing these cells and Actinophryans for further examination, when I observed that one of the spore-like cells had become ruptured, and that a portion of its protoplasm, charged with the triangular starch-grains, was slightly protruded through the crevice. It then struck me that the Actinophryans had obtained their starch-grains from this source; and while looking at the ruptured cell, an *Actinophrys* made its appearance, and creeping round the cell, at last arrived at the crevice, from which it extracted one of the grains of starch mentioned, and then crept off to a good distance. Presently, however, it returned to the same cell; and although there were now no more starch-grains protruding, the *Actinophrys* managed again to extract one from the interior, through the crevice. All this was repeated several times, showing that the *Actinophrys* instinctively knew that these were nutritious grains and that they were contained in this cell, and that, although each time after incepting a grain it went away to some distance, it knew how to find its way back to the cell again which furnished this nutriment. Fig. 6 is a sketch of this, taken at the time, and here reproduced to make the fact more intelligible and impressive.

On another occasion, I saw an *Actinophrys* station itself close to a ripe spore-cell of *Pythium*, which was situated upon a filament of *Spirogyra crassa*; and as the young ciliated monadic germs issued forth, one after another, from the dehiscent spore-cell, the *Actinophrys* remained by it and caught every one of them, even to the last, when it retired to another part of the field, as if instinctively conscious that there was nothing more to be got at the old place (fig. 7).

But by far the greatest feat of this kind that ever presented itself to me was the catching of a young *Acineta* by an old sluggish *Amœba*, as the former left its parent; and this took place as follows:—

In the evening of the 2nd of June, 1858, in Bombay, while looking through a microscope at some *Euglenæ*, &c., which had been placed aside for examination in a watch-glass, my eye fell upon a stalked and fixed triangular *Acineta* (*A. mystacina*?), around which an *Amœba* was creeping and lingering, as they do when they are in quest of food. But knowing the antipathy that the *Amœbæ*, like almost every other infusorium, have to the tentacles of the *Acinetæ*, I concluded that the *Amœba* was not encouraging an appetite for its whiskered companion, when I was surprised to find that it crept up the stem of the *Acineta* and wound itself round its body. This mark of affection, too much like that frequently evinced at the other end of the scale, even where there is mind for its control, did not remain long without interpretation. There was a young *Acineta*, tender, and without poisonous tentacles (for they are not developed at birth), just ready to make its exit from the parent—an exit which takes place so quickly, and is followed by such rapid, bounding movements of the now ciliated young *Acineta*, that who would venture to say, *à priori*, that a dull, heavy, sluggish *Amœba* could catch such an agile little thing? But the *Amœbæ* are as unerring and unrelaxing in their grasp as they are unrelenting in their cruel inceptions of the living and the dead, when they serve them for nutrition; and thus the *Amœba*, placing itself round the ovarian aperture of the *Acineta*, received the young one, nurse-like, in its fatal lap, incepted it, descended from the parent, and crept off. Being unable to conceive at the time that this was such an act of atrocity on the part of the *Amœba* as the sequel disclosed, and thinking that the young *Acineta* might yet escape, or pass into some other form in the body of its host, I watched the *Amœba* for some time afterwards, until the tale ended by the young *Acineta* becoming divided into two parts, and thus in their respective digestive spaces ultimately becoming broken down and digested (fig. 8, &c.).

A little liberty has been taken in the verbal description of this act to lessen the tediousness of the account; but the facts remain the same, and evince an amount of instinct and determination of purpose which could hardly have been anticipated in a being so low in the scale of organic development as *Amœba*.

Observations.—On comparing the assumed reproductive cells of *Amœba princeps* with those of *Æthalium*, there is the difference that, while in the former they are confined to a few, all of the same size, in the latter they are innumerable and of all kinds of sizes. In the former, again, each cell probably produces but one *Amœba* (although it is true that the granulated protoplasm may produce as many as there are granules in each reproductive cell), while in the latter there is a rapid endogenous development of nuclei and nucleated cells within cells. In adult *Amœba* the reproductive cells are comparatively few and distinct, while in *Æthalium* they form a confused mass, as regards number, size, and contents, which is hurrying on, fungus-like, to the production of an infinitude of sporidia. The apparent absence of a nucleus in the reproductive cells of *A. princeps* (while it is present in all those of *Æthalium*) probably arose from my not having been able to detect it. I can hardly conceive that these cells can be without a nucleus.

Ultimately, the semifluid mass of *Æthalium* gathers itself up together like that of *A. princeps*; its membranes become effete, and, the endogenous cell-development having gone on to its full extent, the parent cells are congregated and dried up together, while their reproductive granules, on passing into the state of sporidia, secrete a hard capsule around themselves respectively, which ultimately becomes of a dark brown colour.

In other forms of the Myxogastres, the mother cells shoot up from the surface of the semifluid mass into pin-head or elongated-capitulated forms, approximated or isolated, of great beauty, where, as in *Diachæa* and *Stemonitis*, there are a central stem and arborescent, reticulated, filamentous branch-works respectively, and in *Trichia* even *elaters*. So that the ultimate development of the Myxogastres, however much it may resemble that of *Amœba* at the commencement, is much more allied to plants in the termination.

The varied outward forms of most exquisite beauty, and the brilliant colours, to say nothing of the intricacy of the internal structure, of the Myxogastres (all developed, as they are, from a repulsive-looking slime at the beginning, but, in its polymorphic power, creeping in long lines, or ramifying in an arborescent anastomosing network, ever changing its shape, and everywhere presenting a rapid circulation of its internal contents, isthmusing itself in one part to disunion, and uniting itself in approaching branches in another, through which the incessant flow of granules takes place directly, as though it had been the work of time and trouble rather than produced faster, almost, than the eye can follow the union), make this group of beings, to whatever class they may ultimately be shown to belong, at once one of the most wonderful and the most exquisitely beautiful on the face of the earth. If any one would rightly understand the behaviour of the protoplasm of the plant-cell in all its varied and perplexing movements, he will find the key in the study of *Æthalium*.

Like, however, as *Æthalium* may be to plants in its ultimate development, its sporidium, as M. A. de Bary has shown, splits and gives exit to a mono- or diplo-ciliated polymorphic cell, with contracting vesicle and nucleus, which ultimately losing its cilia, becomes reptant, and, in this condition, cannot be distinguished from a common *Amœba*; and these small *Amœbæ* again grow into larger ones, which, it may be fairly assumed, finally form masses of slimy *Æthalium*, that may attain many inches in diameter, and reach even a foot in length, before their cell-development is completed and their maturity sufficiently advanced for them to gather themselves up into a cake-like, effete mass filled with the chambers (cells) of sporidia to which I have already alluded—living atoms of the old being, left for the multiplication and perpetuation of the species.

Thus, although *Æthalium* is an animal in the first part of its existence, it, through *Diachæa*, *Stemonitis* &c., and *Trichia* (which, as just stated, produces *elaters* among its sporidia), is thus more nearly allied in the structures of its fructification to the vegetable kingdom.

Forming a still narrower link between the freshwater Rhizopoda and the Myxogastres, are those beings which prey upon the contents of both animal and vegetable cells (viz. protoplasm, fat, and starch), but most noticed because perhaps most evident in the bodies of the Protozoa and in the cells of Algæ.

I showed, many years since, that a mass of rhizopodous (commonly called fungous) cells lived and grew habitually *in* the circulating protoplasm of the cells of Characeæ (in Bombay*), and therefore could only have existed there by nutrition indirectly brought to them through the plant-cell in which they were living; but that the moment anything happened to destroy the vitality of the plant-cell, then they instantly divided the cell-contents among themselves, each enclosing, like an *Amœba*, as much as it could catch; after which, each cell or individual, assuming a spherical or globular form, encapsuled itself, abstracted the nutritious part of the enclosed plant-cell-contents in an inner cell, withdrew its thus enriched protoplasm from the refuse, and, again, forming a third cell, ultimately produced in this (from a granulation of the nucleus?) a number of mono- and diplo-ciliated polymorphic cells, which, some time after, issuing from the effete parent cells into the water, lost their cilia, and became small reptant amœbous Rhizopods.

Again, in *Spirogyra crassa* I have described an actinophorous Rhizopod which breeds, after the same manner, in the cells of this confervoid Alga at Bombay†. And during the month of April last (1863), I witnessed a similar development in the cells of the same Alga in England; but in this instance the product was purely amœbous, that is, without actinophryan rays. For these species Pringsheim has proposed the generic name of "*Pythium*;" but whether either of those just mentioned is his *P. entophytum* I will not stop to discuss. Be this as it may, they both put forth filamentous root-like prolongations (fig. 7 *b*), so much like *Mucor stolonifera*, Corda, and the mycelium of Fungi, that they are in this respect just as nearly allied to Fungi as the Myxogastres in their way; and yet here there is no doubt that the new brood is produced from nutriment incepted in a crude state, like that of *Amœba*.

Lastly, *Achlya* is so closely allied to *Pythium* that it has been placed by Pringsheim in the same family, while Cienkowski "has confirmed the idea formerly entertained," that *Achlya* is but an aquatic form of *Mucor* ‡.

Now, about two years since, I noticed, among the dark pin-

* Ann. Nat. Hist., vol. xvii. p. 101 (1856).
† *Ibid.*, vol. xix. p. 259 (1857).
‡ Micrographic Dictionary, Griffith and Henfrey.

head fructification of *Mucor stolonifera*, that there were some colourless heads which had not the usual round form, but, on the contrary, were spear-pointed; and when placed under the microscope, it was evident that the mass was composed of a number of spherical cells, which, for want of the usual common capsule, had, by gravitation, descended the stem, and had thus caused the capitulum (peridiole) to present the shape mentioned. After this, on watching the mass, which was in water under a slip of thin glass, I saw that each cell took on the form of an *Amœba*, and in a short space of time the whole bunch were creeping away in different directions, and the entirety of the capitulum had thus become destroyed.

Furthermore, I observed that when the stems or the filaments of the mycelium of this *Mucor* were cut across and pressed under water, their contents issued forth in the form of spherical, plastic, nucleated cells, which, although so delicate that, by the imbibition of water, they soon burst and disappeared, yet retained their form sufficiently long for me to observe in them a certain amount of polymorphism, which, together with their size, bore a close resemblance to the cells which composed the imperfectly formed peridiole. Thus the whole tubular filamentous skeleton of *Mucor* would appear, as in other instances, to be formed upon a group of polymorphic cells. I shall not go into the detail of the formation of the reproductive cells of *Mucor* and *Achlya*. Suffice it to say that in the former the peridiole or capitulum is filled with brown capsuled sporidia, like those of *Æthalium*, while in *Achlya* it is filled with mono- or diplo-ciliated polymorphic cells, which in their primary form are spherical, like those of *Pythium* (fig. 7 *d*).

But each of these forms of *Mucor* has a filamentous mycelium, with the stems (columellæ) of their fructificating heads (peridioles) divided by septa into distinct cells; while *Pythium* has just the same kind of filamentous mycelium, with (when it fructifies under this form) a dilatation at the end of the bunch of root-like filaments into a spore-cell (analogous to the peridiole of *Mucor*), which produces a number of monadic cells like those of *Achlya* (fig. 7).

I do not know what changes the reproductive cells of *Mucor* or *Achlya* may undergo in the first part of their life, but I should think that they were like those of *Pythium* and *Æthalium*, which have been above described.

Thus *Pythium* produces, then, a fungous mycelium, like *Mucor* and *Achlya*, and at the same time that the latter are identical, all three only differ from *Æthalium* and the Myxogastres generally in their internal contents (viz. cells) growing, after a certain period, under a cellulose (?) coat, instead of nakedly, which causes the former to present a plant- or fungus-like constant figure, which, in the Myxogastres, is continually varying up to the moment that they end in a rapid consolidation of their fructifying ingredients. So in *Mucor*, the germinating cells of the peridiole rapidly pass from a colourless plastic form into a hard, dry, dark brown capsuled one; while in *Achlya*, or the aquatic form of *Mucor*, the capsule is colourless, and so evanescent that the young are put forth from the peridiole almost viviparously. It is easy, therefore, to see here why the germs of the aërial form are wrapt up in a dense capsule, while those of the aquatic one do not need any.

But I am straying away from the point, although, from what I have above stated, it will now, I think, be satisfactorily seen that *Æthalium*, for the greater part of its life, lives like *Amœba*, and that, although there may be a little difficulty in proving that the foreign particles seen in the great masses of *Æthalium* have been taken in for food, still *Pythium*, which has a kind of mycelium and is thus intimately allied to *Achlya* (which, again, is but an aquatic development of *Mucor*), does undoubtedly take in crude material for food identically with *Amœba*.

Whether the Myxogastres are entitled to the new name of "Mycetozoa" (proposed for them by M. A. de Bary) under these circumstances, or not, I leave others to determine. There are no absolute lines of demarcation here more than anywhere else, and therefore common sense, aided by progressive knowledge, must be appealed to for decision also here as well as elsewhere.

Although not immediately bearing on the subject, I would just revert to the statement I have made respecting the light which the study of *Æthalium* throws on the behaviour of the protoplasm of the plant-cell; for there is yet another point to be considered, viz. how does the protoplasm obtain an external communication so as to produce materials which are found *outside* the cell-wall and keep up a communication alone with the *external* world, as in the unicellular Algæ, or when in combination with other cells, as in the plant? This important question seems to receive solution from M. Garreau's observations, who states that there are filaments of the protoplasm which pass from the primordial membrane through holes in the cell-wall*; and if this be confirmed, it will lead to such a chain of explanations in the development and habits of the vegetable cell, separate and in combination, as has for some time past been unparalleled by any other similar discovery.

* Ann. Nat. Hist. vol. x. p. 43 (1862); translated from Ann. des Sc. Nat. 1860.

EXPLANATION OF PLATE III.

N.B.—All the figures in this plate are diagrammatic, in so far as it is impossible to give the relative sizes of the different parts of which they are composed, intelligibly, without enlarging them to an extent which would be incompatible with the size of the plates in the 'Annals;' nor is it necessary.

In all the figures of *Amœba*, the ground-shading stands for the sarcode and its moleculæ, while the other specks and dots represent the granules and fat-globules respectively.

Fig. 1. *Amœba princeps*, about $\frac{1}{60}$th of an inch in length, with somewhat less breadth; greatly magnified: *a*, the granules and fat-globules; *b*, vesicula or contracting vesicle; *c*, reproductive cells, upwards of 32, and all $\frac{1}{1800}$th of an inch in diameter; *d*, smaller granuliferous cells; *e*, large globular transparent cell, $\frac{1}{900}$th of an inch in diameter, with small granuliferous nucleus; *f*, villous tail; *g*, *h*, *i*, forms of the granules, the largest about $\frac{1}{2000}$th of an inch long; *g*, aggregated octahedral form; *h*, ditto, still more compound (composed of oxalate of lime?); *i*, elliptical or earlier form of granule; *k*, fat-globules; *l*, *m*, *n*, assumed reproductive cells, more magnified; *l*, oval form; *m*, spherical ditto, both without distinct capsule and without granules; *n*, ditto, under the effect of iodine, showing minute granules, but no capsule.

Fig. 2. Ditto, about $\frac{1}{70}$th of an inch long, representing the "granulation of the nucleus": *a*, the granules; *b*, vesicula; *c*, nucleus, $\frac{1}{700}$th of an inch in diameter, capsular, with nucleolus granulated; *d*, villi of tail, dilated into a vesicular form, giving a crenulated aspect to this part; *e*, spherule, like a fat-globule, occasionally discharged from the tail, and afterwards bursting, when the capsule remains, and the contents appear under the form of a group of swarming little molecules, which adhere for some time to the end of the *Amœba*; *f*, nucleus, of an oval form, $\frac{1}{500}$th of an inch long, more advanced in granulation and from a larger and older specimen of *A. princeps*; granules spherical, and about $\frac{1}{1400}$th of an inch in diameter.

Fig. 3. Ditto, about $\frac{1}{250}$th of an inch long, showing—*a*, vesicula; *b*, nucleus divided into two; *c*, villous tail; *d*, nucleus, much magnified, about $\frac{1}{1200}$th of an inch in diameter, showing its characteristic appearance in *A. princeps*; *e*, transparent area left by the nucleolus; *f*, daughter nuclei, the result of the first division.

Fig. 3′. Ditto, very small specimen, about $\frac{1}{450}$th of an inch long: *a*, vesicula and villous tail; *b*, nucleus.

Fig. 4. Ditto, nearly effete, $\frac{1}{25}$th of an inch in diameter, containing upwards of 74 reproductive cells, each $\frac{1}{1800}$th of an inch in diameter, now consisting of coarsely granular protoplasm within a firm capsule: *a*, granules; *b*, reproductive cells; *c c*, expansions of the diaphane bursting through the thickened pellicula; *d*, reproductive cell, more magnified, under the influence of iodine, showing oval contracted shape of granular protoplasm and spherical cell.

Fig. 5. Ditto, showing—*a*, vesicula; *b*, reproductive cells, among which *c* represents one as yet undivided, which, after division, would make up the number 8; *d*, peculiar form of villous tail; *e*, *Furcularia* biting the *Amœba*. This sketch, as it stands, was made at Bombay, in 1855.

Fig. 6. Fungus(?)-cell, $\frac{1}{100}$th of an inch long, transparent, oval, sometimes subpolymorphic, containing protoplasm (charged with triangular starch-grains) in rotation; *b*, *Actinophrys* extracting the starch-grains.—Of this extraordinary cell, which was found annually in great abundance, among aquatic plants and Infusoria, in a pool in the island of Bombay, which is dry eight months in the year, I hope to publish much more on a future occasion.

Fig. 7. Spore-cell of *Pythium*, on the outer side of the cell-wall of *Spirogyra*: *a*, spore-cell, containing reproductive, polymorphic, ciliated cells; *b*, root-like part of cell (analogous to the mycelium of *Fungi*) *in* the cell of *Spirogyra*; *c*, cell-wall of *Spirogyra*; *d*, reproductive cell, or polymorphic monad, which has left the spore-cell, on its way to being captured by the *Actinophrys* (*e*), in which there are already three such. Sketch made at Bombay, in 1856.

Fig. 8. *Acineta* (*mystacina*?), surrounded by an *Amœba* while in the act of putting forth its young one: *a*, old *Acineta*; *a'*, its nucleus; *b*, young one; *c*, *Amœba* waiting for the young *Acineta*; *d*, *Amœba* after having caught the young *Acineta* (*e*); *f*, ditto, one hour and a half afterwards; *g* shows the young *Acineta* divided into two portions, and now being digested in separate spaces. Sketch made at Bombay in 1856.

Fig. 9. Cell, $\frac{1}{1200}$th of an inch in diameter, containing effete nucleus and short bacilliform filaments.

Fig. 10. Isolated cells of the vesicula or contracting-vesicle system immediately after having been pressed out from *Amœba princeps*.

Fig. 11. The same, after exposure to iodine, showing that they retain their cell-wall, which then becomes crenulated.

V.—*On the Raphides of Rubiaceæ.* By George Gulliver, F.R.S., Professor of Anatomy and Physiology to the Royal College of Surgeons.

In the 'Annals' for January last it was mentioned that raphides occur in all the species which I had then examined of this order. Through the courtesy of Mr. W. H. Baxter, who has supplied me with species of *Rubia*, I am now enabled to complete the series, as far as regards the British plants of the order. *Rubia peregrina* and *R. tinctorum* abound in raphides.

Certain orders, as Onagraceæ and Lemnaceæ, may be so readily distinguished from some of their allies by the raphides alone, that even a minute fragment of the plant, either fresh or dried, may be sufficient for the diagnosis, as was shown in the 'Annals' for April last; and now the order Rubiaceæ affords an additional illustration, the value of which may be easily tested as follows. In Professor Babington's excellent 'Manual of Botany,' we find this order, which we have just seen affording raphides, standing between Caprifoliaceæ and Valerianaceæ, two orders which we have found to be equally remarkable as devoid of raphides.

The raphides here meant are the needle-like forms occurring,